DOCUMENT RESUME

ED 226 961 SE 040 374

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TITLE	Project TOPS. Final Evaluation Report. Math Research and Evaluation Studies.
INSTITUTION	CEMREL, Inc., St. Louis, Mo.
SPONS AGENCY	Department of Education, Washington, DC. Basic Skills Improvement Program.
PUB DATE	Oct 82
CONTRACT	300-800-954
NOTE	84p.; For related document, see ED 223 421.
PUB TYPE	Reports - Research/Technical (143)
EDRS PRICE	MF01/PC04 Plus Postage.
DESCRIPTORS	Basic Skills; Curriculum Development; Educational Research; Elementary Secondary Education; *Inservice Teacher Education; *Mathematics Curriculum; *Mathematics Education; *Mathematics Instruction; *Problem Solving; Teacher Education; Testing; Test Items
IDENTIFIERS	*Mathematics Education Research; *Project TOPS

ABSTRACT

TOPS, a set of materials designed to improve problem solving instruction, was evaluated in two large urban school districts from Fall 1980 to Spring 1982. At Site A, the program was implemented at the middle school level (grades 5-8), where most mathematics teachers were specialists; they accepted the problem-solving activities after some initial hesitation. At Site B, the program was implemented in grades 3-8, though most often in grades 4 and 5, usually by teachers who were not mathematics specialists. They varied in their belief that the activities would improve problem-solving ability, and, even though in year 2 they were allowed to develop lessons involving problem-solving strategies tied more closely to textbooks and tests, problem solving was never completely accepted by all teachers. At Site A, 80 teachers were trained, eventually affecting over 300 classes, and the school board pledged continued support. At Site B, progress was slower. Two major effects were noted at both sites: (1) teachers viewed TOPS favorably and commented on its positive impact on students' mathematics and thinking skills; and (2) TOPS students had better test scores than non-TOPS students; differences were significant at Site A but not Site B. (MNS)

ED226961

Project TOPS

Final Evaluation Report

Math Research and Evaluation Studies

CEMREL, Inc.

October, 1982

Martin C. Herbert
Gail Marshall

Funded by
Contract No. 300-800-954
Basic Skills Improvement Office
United States Department of Education

SE040374

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SUMMARY

TOPS goals were twofold: to train a corps of teachers capable of teaching problem solving as well as training other teachers to do the same, and to improve students' problem solving in mathematics.

Summary of Implementation. TOPS was implemented differently at the two sites. At Site A, the program was implemented at the middle school level (grades 5 - 8), where most math teachers were specialists who teach mathematics throughout the day. For the most part, the original group of TOPS teachers was a relatively strong group which might be expected to take a leadership role in future TOPS expansion. After some hesitation, mathematical problem solving as exemplified by the TOPS activities was accepted at Site A. This was in spite of the fact that this problem solving was never clearly articulated as measurable and seemed not particularly consonant with the district's standardized tests.

At Site B, the program was implemented at grades 3 - 8, though most often in grades four and five, and usually by teachers who were not mathematics specialists. The most important criterion for selecting a school was low scores for the school on district administered achievement tests. The original group of teachers did not have a particularly strong background in mathematics and participants varied in their belief that TOPS activities would lead to improved problem solving ability, especially as measured in standardized tests. A redirection of the program in Year II at Site B broadened and diffused the instructional emphasis. Teachers could choose from

several kinds of instructional materials; there was more emphasis on having teachers develop their own lessons which were to emphasize classical, psychological problem solving strategies; and instruction was tied more directly to the regular district textbook and standardized testing programs. Even with this freedom to tailor TOPS to locally perceived needs and local materials, problem solving was never completely accepted by all the teachers, but was viewed by some as competing for math instruction time.

The two approaches led to quite different implementation results. At Site A, approximately 80 junior high mathematics teachers were trained, eventually impacting over 300 classes. The school board pledged support to continue training of new teachers next year with local funds and the long range goal is to train all middle school teachers. TOPS goals do not particularly match those of the present district-administered test. As a result, the TOPS program has provided an impetus at Site A to develop, over the next few years, a new series of tests in mathematics. They will emphasize problem solving and become part of the district's testing program.

At Site B the undertaking was in a sense, more ambitious, in that "generalist" teachers who taught in elementary schools and who had a less strong mathematics background formed the first group of trainees. This emphasis on training the generalist teachers, and elucidating for them the more generally accepted strategies of problem solving with a very careful eye towards standardized test performance, may make the goals at Site B more appealing to some school administrators. But progress is bound to be slower and more difficult because of the need to train teachers in the mathematics <u>and</u> in the problem solving strategies. These needs are compounded by the need for teachers to develop for themselves lessons embodying the mathematics and the strategies. A major problem for teachers who want to teach problem

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solving daily as an adjunct to the text given the absence of good curricular materials are available for teaching these particular strategies.

Summary of Effects. There were two major effects. They were:

I. At both sites, participants viewed TOPS favorably and commented on its positive impact on students' mathematics and thinking skills.

II. At both sites, TOPS students had better test scores than Non-TOPS students. But in spite of consistently higher scores, the differences were statistically significant at Site A but not at Site B; the scores do suggest TOPS fosters problem solving development.

Both findings are worth amplifying:

I. Overall, TOPS was considered successful by participants. All participants viewed the TOPS project favorably. The majority of teachers thought that their ability to teach TOPS had improved since last year and also indicated they were capable of continuing to teach TOPS next year and would be likely to do so. The majority of teachers indicated that TOPS had a beneficial effect on their students and Coordinators favorably reviewed the majority of lessons, the impact on students and teacher's mastery of those lessons.

According to participants, the TOPS approach, designed and executed by the CEMREL staff, was a challenging, substantive, and productive way to teach problem solving. As an alternative to current texts and materials, TOPS was appreciated by some, if not all, of the teachers. For teachers who wanted to teach problem solving but couldn't find an entree, TOPS worked, and all participants regardless of problem solving expertise commented favorably on TOPS quality, and on the ability of CEMREL's TOPS staff and their local staff to introduce the teaching or problem solving as well as they did. Particularly appreciated was the role defined by TOPS for the Coordinators. By casting them in the role of consultants and collaborators (as opposed to supervisors), the project designers set the stage for interactive professional development that teachers found helpful.

II. Student Achievement. At Site A, TOPS classes had significantly higher scores than Non-TOPS classes on the MANS Tests, a special series of problem solving tests. The adjusted mean scores were 128 (for six seventh grade TOPS classes) versus 110 (for six seventh grade Non-TOPS classes). These TOPS classes also had higher scores, by about 10%, on the Concepts and Applications test of the California Achievement Tests, although this difference did not reach statistical significance. There are two factors which make these findings especially noteworthy. First, when problem solving is measured by tests which do not test directly what was taught (i.e., are new to students, as was the case in Site A), significant differences between curriculum groups are not usually found. Second, most of the TOPS students had only one year of TOPS instruction; one can expect even stronger results if students study TOPS throughout middle school.

At Site B, TOPS students had higher scores than Non-TOPS students, but the differences were not statistically significant. On the California Achievement Tests, Concepts and Applications, for nine fourth grade TOPS classes the adjusted mean scale score was about 431 versus about 425 for eight Non-TOPS classes. The mean score for a scattered group of fifth grade TOPS students completing their second year of TOPS was about 469 versus about 461 for a comparable Non-TOPS group.

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Differences between the two sites in teachers' background and program implementation are instructive. We conclude that districts which train "specialist" teachers, who teach mathematics to several classes each day, will get a better return on their training investment. Since these teachers need to spend less time learning the mathematical processes embodied in TOPS, more time is available for observing and practicing TOPS teaching techniques. On the other hand, a district which decides to adopt TOPS in order to give less mathematically able teachers an introduction to mathematical processes of problem solving, as Site B did, will need more time for training and that training will be a more difficult undertaking.

Districts also need to make an explicit commitment to the teaching of problem solving. Teachers need assurances that their attempts will be supported and sustained, and that evaluations of TOPS impact on students will bear some relationship to instruction. Evaluation attempts also need to recognize that the implementaton process and its effects on students may happen slowly.

Given those conditions, TOPS can make a positive contribution to districts interested in improving the mathematical problem solving abilities of their students.

INTRODUCTION

TOPS, a program designed to teach problem solving in mathematics, was developed by CEMREL staff and implemented by that staff in conjunction with administrators and teachers at two pilot sites, Site A and Site B, from Fall, 1980 to Spring, 1982. Both sites are large urban school districts. TOPS goals were to train teachers to become capable of teaching effectively for problem solving there by improving students' problem solving skills. Special emphasis was placed on improving students' facility with applications and with higher level cognitive skills, rather than computation.

Need for the Program

Impetus for the project came from several sources, among them NCTM's statement that problem solving in mathematics should be an important part of mathematics instruction. A similar statement by the National Council of Supervisors of Mathematics served to underscore the importance of problem solving in the curriculum. Both groups supported teaching problem solving at a time when students' standardized test scores, especially in mathematics, were lower than they had been in a decade. As a result, school districts began looking for curriculum materials and instructional techniques that emphasized problem solving.

TOPS: A Proposed Solution to Districts' Need for a Problem Solving Curriculum

CEMREL's CSMP staff had developed, over a number of years, a mathematics curriculum which stressed a problem solving approach to computation, number relations, and other mathematical topics.

TOPS was designed from components of the program with the goal of teaching problem solving to elementary school students one day a week. Both CSMP and TOPS are based on the assumption that problem solving lies at the heart of mathematics, and should be taught as part of students' mathematics instruction. To achieve this goal, TOPS materials and strategies, like CSMP, were developed from ideas found in advanced mathematics and were designed to supplement students' standard mathematics curriculum.

TOPS goal of training teachers in problem solving was based on the assumption that teachers could be taught how to appy problem solving techniques in their own classrooms. Accordingly, training was targeted to the TOPS staff helping teachers learn and apply problem solving strategies. First, in workshops, and then through Coordinator classroom visits as the teacher taught TOPS in lieu of the textbook one day a week. It was anticipated that the combination of training and practice, monitored by district level coordinators, would enable the teachers to increase their districts' ability to teach problem solving to more and more students each year, and as a result create long range improvement in problem solving in each district.

As TOPS was conceived, both goals were to be met by using techniques, materials, and strategies based on a specific point of view which was operationalized via five major sets of activities: the Language of Arrows, the String Game, the Mini-computer, Hand Calculator, and Detective Stories. They combine mathematical content, like number relations, with basic cognitive processes, like discovering a pattern which describes the relations. Since presenting the content calls for a specific style or teaching, and TOPS is based on a point of view which is not widely known, teacher training is necessary. Conceptualization not computation lies at the core of the program, which means a TOPS classroom may not resemble the typical classroom in which teachers learned or previously taught mathematics. In the beginning, teachers need consultations in planning and teaching lessons to foster their development of students' problem solving.

Evaluating TOPS

In evaluating TOPS, the dual goals of training teachers and improving students' problem solving served as focal points for the evaluation questions. The two key issues, which shaped the evaluation, were:

- Was TOPS, as envisioned by its developers, successfully implemented at each site?
- Did TOPS participation affect students' mathematical problem solving ability?

A third question:

- What is the likelihood of a program like TOPS succeeding at other sites?

is also addressed. To answer the three questions, data were gathered from several sources:

- Interviews with coordinators, principals and teachers.
- Questionnaires distributed to all project teachers at the end of each project year.
- Classroom observation data.
- Test data.

and analyzed to produce answers to the questions.

TOPS implementation did not proceed as originally planned at both sites.

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At Site A implementation was continued as planned during Year II, but at Site B there were changes in program structure and focus, in personnel, and in continuation/expansion prospects. Those changes rendered the two sites different, hence the data from each site are best presented separately. (For information about Year I of TOPS see <u>Project TOPS: First Year Evaluation Report</u>. Martin Herbert and Gail Marshall. CEMREL, Inc., St. Louis, Mo., 1981.)

SITE BACKGROUND INFORMATION

This section will briefly describe the commonalities at the two sites and the remainder of the report will describe differences in the implementation and impact of TOPS; first at Site A, and then at Site B.

The Sites

Site A is a large mid-western urban school district. A major manufacturing center, its urban area typifies the economic, social, and educational profile of many large American cities. A downtown decaying and rebuilding, white flight, and a high concentration of poor and unemployed mark the problems faced by the school administrators. Site B is a middle sized urban school district where both heavy and light industry provide a more diversified economy. However, like Site A, its problems are typical of cities its size.

Site Events

The contract for TOPS began October 1, 1980. At each site a district level Coordinator was chosen by site administrators and a Demonstration Teacher was chosen to work with the Coordinator. Following the selection of these district level staff, who were to be chosen because of their mathematics training and their administrative experience, schools and teachers were chosen. In some cases, schools and teachers were selected because of low test scores in mathematics. In some cases, teachers volunteered for the program and their classes did not necessarily follow that pattern. In still other cases, the teachers chosen were those who needed special help in learning or teaching mathematics, as perceived by a principal or other administrator. This happened more frequently at Site B.

Once the staff and teachers were chosen, the first series of workshops at the sites was scheduled for mid-November, 1980. At Site B, the workshop was held as planned (November 12-14), almost three months after school began, a beginning which was later than originally anticipated. But at Site A, district level decisions led to the postponement of both the November workshop and one rescheduled for December. The workshop was finally held January 20-22, 1981. Since formal TOPS teaching began the Monday immediately following the workshops, Site A TOPS instruction began halfway through the school year.

There were four major differences between the two sites which had implications for the day-to-day conduct of the project and for the future of the project. These differences, which will be discussed in turn, were:

- Staff experience and training
- Schedules for teaching TOPS
- Definition and operationalizing of problem solving.
- Plans for continuation and expansion

Staff Experience and Training. Analysis of the questionnaires completed by staff at both sites (Appendix A) showed that the Coordinator and Demonstration Teacher at Site A had more formal mathematics training and more experience teaching and supervising mathematics classes than the Site B staff.

Teachers at Site A had more formal mathematics training; more of them had a major in mathematics or a concentration of mathematics courses as undergraduates. Site A teachers often taught TOPS at several grade levels and they taught only Math to those classes. Site B teachers were more likely to teach Math and other subjects, and most often taught elementary classes.

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Thus, Site A teachers could be considered "specialist" teachers, whose primary responsibility was to teach mathematics. By virtue of their training and their assignments in schools, they were specializing in mathematics instruction. Most Site B teachers could be regarded as "generalists", teachers trained to teach a wide variety of subjects and assigned to a particular grade level.

A second difference in staffing also occurred at Site B. On the recommendation of the Federal Project Officer, the two Demonstration Teachers, each of whom had worked half time on the project, were replaced by a full-time Demonstration Teacher at the end of Year I. This change meant that the Coordinator had to acquaint the new Demonstration Teacher with the project while planning for the second year in-service, and had to re-schedule classroom visits, since the previous year's schedule (predicated on two part-time staff members) was no longer workable. The Demonstration Teacher had not participated in Year I in-service meetings and seminars with CEMREL staff, and was therefore not aware of the point of view and operational strategies which had been implemented at Site B during Year I.

Scheduling. A second mandated change from the Federal Project Officer affected the teaching of TOPS at Site B. Concerned about the match between TOPS goals and the district goals, a match which had been questioned by the Coordinator and several teachers, the Federal Project Officer directed TOPS teachers to teach problem solving for a few minutes each day in conjunction with topics and problems covered in the local textbook. At Site A, teachers continued to teach TOPS once a week as originally envisioned by TOPS planners, but at Site B, a new schedule had to be worked out by the teachers, and new ways of integrating TOPS had to be devised. In fact, this mandate to teach

TOPS every day crystallized a latent problem at Site B. Several teachers, not strong in mathematics to begin with and just beginning to gain mastery of the TOPS materials and concepts, were unable to integrate them into their local textbook program. For example, some teachers were able to see the applicability of the Mini-computer to place value lessons, or the String Game to factoring, but other teachers were at a loss as to how to use TOPS materials and strategies as adjuncts to the text.

Definition and teaching of problem solving. At Site A, teachers continued using the types of TOPS lessons which they had practiced the year before, as well as refining their use of the problem solving strategies embodied in them. At Site B, the mandate by the Federal Project Officer resulted in a wide range of implementation strategies. The net result was a melange of classroom instruction at Site B, some of which could be called problem solving using a TOPS focus, some of which was a more generic form of problem solving, and some of which had no discernable problem solving orientation.

The differences in teachers' intuitive definitions of problem solving and in their willingness to accept TOPS materials and concepts, appeared to be related to their mathematics training. Teachers who had had a concentration in mathematics and/or taught Math to several grades each day (as at Site A) were more likely to maintain fidelity to TOPS lessons and to use TOPS materials and strategies to focus on the problem solving aspect of the materials. Their mathematics prepared them to understand and maximize the lessons. For teachers with weaker mathematics backgrounds (typically at Site B), TOPS was usually nothing more than an introduction to problem-solving strategies and to non-computationally oriented mathematics.

Continuation and Expansion. In August, 1981 while Site A was in a position to build on and improve the first year's work, Site B, for all intents and purposes, had to begin anew. Since the changes mandated by the Federal Project Officer had introduced a new staff, a new teaching schedule, and a new problem solving focus, some teachers were confused about the actual purpose of TOPS instruction. Hence they were not effective advocates of the program. More detrimental to continuation and expansion efforts however, was the fact that a major portion of the introductory workshop sessions at Site B in 1981-1982 had to be devoted to explaining the changes to the original group of TOPS teachers. Schedule changes and their concurrent reporting requirements also commanded time and energy. This meant the Coordinator had no time to think about training a second cadre of teachers or helping TOPS teachers train other teachers in their buildings. Instead, four replacement teachers were phased into the project by participation in Year II activities. While the new staff brought insights and skills that contributed to the project, working relations with project teachers in some cases had to be built from scratch.

The Site A Coordinator and Demonstration Teacher, on the other hand, were able to spend the first few weeks of Year II reviewing TOPS teachers' work and introducing a second cadre of teachers to TOPS. Later in the year, they were able to monitor both groups, and introduce a third group of teachers to TOPS. This expansion resulted from the continuity of efforts which characterized Year II at Site A.

The differences between the two sites affected TOPS implementation and impact. Both issues will be discussed in the next section.

TOPS IMPLEMENTATION: SITE A

Data in this section were gathered by means of questionnaires mailed to TOPS teachers in Spring, 1982. Twenty eight teachers returned completed questionnaires : twelve were teachers who had been in the project last year (69% of the veteran teachers) and sixteen joined the project during Year II (34% of the the new teachers). Thus the data reported below represent some, but not all, of the teachers currently teaching TOPS at Site A. Data from veteran and new teachers were aggregated in all cases except where the responses of veteran teachers differed from those of the new teachers.

1. <u>Background and Experience</u>. The Coordinator had advanced degrees in Mathematics and extensive experience as a Mathematics supervisor at the middle school level. The Demonstration Teacher had experience with CSMP as well as Mathematics supervisory experience. In the tables which follow, data describing teachers' background and experience are presented.

Teachers' Background and Experience

Number of Years Teaching

1st year 0%
2 - 5 years 18%
6 - 10 years 35%
10 - 20 years 31%
20 plus years 16%

Highest Academic Status Attained

Bachelor's plus 31%, Master's 48%, Master's plus 21%

College Preparation

Elementary education major with no math methods courses	Elementary education with 1 or 2 math methods courses	Another major with some math courses	Concentration in mathematics
0%	30%	30%	40%

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The majority of the teachers tend to be experienced teachers, have received advanced degrees, and have taken mathematics courses in college. As a group, the new teachers had more experience, a better background in mathematics, and were more likely to have volunteered for TOPS (as opposed to being selected) than the veteran teachers.

2. Teaching Schedule. Twenty-five of the twenty-eight teachers taught math at least four times a day, usually in at least two different grade levels. All were middle school teachers (grades five to eight) and all but one of the teachers taught TOPS one full math period per week.

3. TOPS Teacher Training. Before beginning their TOPS teaching, the teachers attended a week long workshop. Conducted by CEMREL'S TOPS staff in conjunction with the local Coordinator and Demonstration Teacher, the workshop was designed to acquaint them with TOPS materials and strategies. Their reactions to this workshop, and to the day-to-day Coordinator activities which followed the workshop, are summarized below from questionnaire data. (A listing of teachers' evaluations is shown in Appendix A.)

Distribution of Workshop Topics and Ratings of Effectiveness

	Average Percent of time	Ratings		
Overview of the program's philosophy and goals	13%	69% effective	25% somewhat effective	6% not effective
Discussion/presentation of math content by trainer	24%	85% effective	12% somewhat effective	3% not effective
Demonstration/discussion by trainer of specific lessons	47%	91% effective	9% somewhat effective	0% not effective
Practice by participants teaching various lessons	16%	66% effective	17% somewhat effective	17% not effective

Strengths and Weaknesses of the Workshops. Several teachers agreed that too much material was covered in too short a time, and they would have liked to have learned a small segment, practiced it, and then met again for another segment.

On the positive side, teachers liked the demonstrations of lessons and the opportunity for participants to practice, especially with students present.

Strengths and Weaknesses of Coordinator Activities. Only one negative aspect of the Coordinators' activities was mentioned: a teacher stated that the observations created tension. All other teacher comments were positive and teachers cited the knowledgeability and helpfulness, the offering of ideas, and the demonstration of new and different ways to deal with students as strong features of the training.

Rating Coordinator Activities.

"If a Coordinator were available next year, what activities would you like to see emphasized?"

	very helpful	somewhat helpful	not usually helpful
Conducting demonstration classes	74%	20%	6%
Reviewing mathematical content	44%	38%	18%
Planning future lessons	48%	52%	0%
Discussing general problem solving strategies	58%	42%	0%
Critiquing lessons you taught	55%	45%	0%
Explaining the goals of an individual lesson	44%	38%	18%
Suggesting classroom management procedures	34%	66%	0%
Classroom visits in general	55%	45%	0%

New teachers, who had more mathematics in college, were <u>less</u> likely than veteran teachers to rate "discussing general problem solving strategies" as very helpful (45% vs. 71%) but <u>more</u> likely to rate "planning future lessons" as very helpful (62% vs. 33%).

4. Teaching TOPS: Distribution of TOPS Lessons

The major part of the TOPS program was the weekly planned lesson taught by the training teacher and often observed and critiqued by the Coordinator or Demonstration Teacher. The teachers kept logs of what was taught and these are summarized below. (Because the length of the TOPS school year differed from Year I to Year II, the percentage of lessons devoted to each strand is shown.)

	Veteran Teachers This Year	Teachers Last Year
String Games	26%	32%
Arrows	25%	17%
Mini-computer	22%	29%
Hand Calculator	11%	17%
Detective Stories	12%	4%
Geometry	4%	1%

Greater uniformity in lesson coverage is shown this year.

5. Coordinator Ratings of TOPS Lessons

During classroom visits, the Coordinator and Demonstration Teacher rated the lesson in a log. Six major aspects of the lesson were to be rated, and the average rating across all observed lessons is given below for each aspect.

Category	Ratings		
	High	Average	Low
Students' Interest	82%	15%	3%
Students' Understanding	83%	10%	7%
Teacher Preparation/Understanding	82%	12%	6%
Teachers' Enthusiasm/Delivery	87%	13%	
	Appropriate	Inappropriate	Had Difficulty
Use of Materials	93%	3%	4%
	Most Students Involved	Strong Students Involved	Weak Students Involved
Teacher/Student Interaction	84%	16%	0%

Another way of analyzing the same log data is to calculate average ratings across lessons according to the content strand of the lesson. These are shown below.

Lessons	Ratings		
	High	Medium	Low
Arrows	78%	17%	5%
String Game	90%	9%	1%
Mini-Computer	83%	16%	1%
Hand Calculator	75%	23%	2%
Detective Stories	93%	7%	

Both analyses show that lessons were generally rated positively by Coordinators.

6. Teacher Ratings of TOPS Materials

This year, like last year, teachers rated TOPS materials "Low" or "High" on five categories.

	String Game		Language of Arrows		Hand Calculator		Mini-Computer		Detective Stories		Mean Rating	
	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
Can be used effectively by a teacher	100%	0%	100%	0%	64%	36%	76%	24%	88%	12%	85.6%	14.4%
Promoting student growth in problem-solving skills	93%	7%	100%	0%	50%	50%	90%	10%	89%	11%	84.4%	15.6%
Promoting positive student attitude toward problem-solving	100%	0%	93%	7%	67%	33%	90%	10%	89%	11%	87.8%	12.2%
Student enjoyment	94%	6%	63%	37%	78%	22%	89%	11%	72%	18%	80.2%	19.8%
Overall benefit to students compared to the math period it replaced	63%	37%	86%	14%	67%	33%	85%	15%	83%	17%	76.8%	23.2%
Mean rating	90%	10%	88%	12%	65%	35%	86%	14%	84%	16%	82.6%	17.4%

Each of the lesson strands received 84-90% high ratings except Hand Calculators which had 65%. Similarly each category received consistently high ratings except "Overall benefit to students compared to the math period it replaced." which still received an average of 77% high responses. Generally, ratings were higher this year than last year.

7. Teachers' Assessments of TOPS' Features

The statements below were generated from negative comments one or more teachers made during observations and interviews conducted in Spring, 1981. (Responses, do not always total 100% because of the pattern of teacher responses.)

	Strongly Agree	Agree	Disagree	Strongly Disagree
Teaching TOPS takes too much preparation time.	___	13%	63%	19%
TOPS ideas can be applied in situations outside TOPS classrooms.	42%	55%	___	___
TOPS does not conflict with our school's math goals.	38%	59%	3%	___
TOPS does not contain enough drill.	3%	22%	61%	11%
Tests should be included as part of the TOPS materials.	8%	49%	40%	3%
TOPS is not useful in any other context.	___	___	63%	29%
TOPS goals are clear.	29%	53%	15%	___
TOPS does not help me learn more about my students	___	3%	68%	29%
The game aspect of TOPS lessens its value.	___	___	63%	37%
Students who have had TOPS this year should continue with TOPS next year.	50%	50%	___	___

In general, these ratings seem to reflect positive teacher attitudes toward TOPS. For most questions, answers were more positive this year than last year. Negative comments received from individual teachers are not widely shared except for the statements referring to TOPS not containing enough drill and the need for test materials as part of TOPS where 25% and 57% respectively agreed with these statements.

8. TOPS Teachers' Views on Teaching TOPS

Having taught TOPS for two years, veteran teachers were in a position to compare their first year of teaching TOPS with their second year. Generally, they noted three changes, 1) better command of the material which lead to the ability to plan and organize their TOPS teaching, 2) greater ability to coordinate the material with the regular curriculum, 3) greater ability to positively affect student achievement.

Veteran and new teachers were asked what changes in their teaching they would make as a result of TOPS teaching. Both groups stressed questioning students more, asking students to explain answers, allowing students to make discoveries, and giving students time to think through a problem on their own.

Asked to discuss persistent problems they had implementing TOPS this year, one teacher cited a problem of sequencing lessons, and two cited difficulties holding and keeping students' attention. Another teacher reported having difficulty allocating time for both TOPS activities and other mathematics activities in the district's curriculum.

9. Teachers' Views on TOPS Continuation

As a result of their TOPS experience, all teachers in both groups, veteran teachers and new teachers, said they would be able to teach TOPS next year; and all but one teacher in the new group would choose to teach TOPS next year.

When they responded to the question "What changes would you make in TOPS next year?", teachers' answers indicated they understood the purpose of TOPS lessons, and agreed with the TOPS approach. For example, teachers said they would ask more questions, and use TOPS materials and techniques more frequently in their regular math classes. They also said they would be more flexible about what days they taught TOPS, perhaps teaching TOPS lessons every day some weeks and a full math period one day a week at other times. Teachers also said they would prefer to initiate Coordinator visits instead of having regular visits scheduled by the Coordinator.

Several teachers said they would need no help next year, several would like workshops scheduled so they could share ideas or receive additional materials and lessons, and others would like only replacement materials and occasional consultations with Coordinators.

An important aspect of TOPS continuation is teachers' ability to do an effective job with it. About half of the veteran teachers said that at least 75% of the teachers of their grade level(s) could do an effective job with TOPS, and about a quarter said between 50% and 75% could do so. All but one teacher, a new teacher, said they would like to see TOPS used in other classes in their schools.

According to teachers, among the problems that new-to-TOPS teachers would face are becoming familiar with and securing TOPS materials, learning to organize and plan with materials, learning how to handle the question-answer dynamics in front of a class, and understanding the goals of the program.

One aspect of continuation of TOPS is teachers' perception of what is needed if they are to continue teaching TOPS. Three separate issues were mentioned:

- There is a need for defining and explaining lesson goals and stating how lessons fit into a sequence of previous lessons.
- There is also a need to design Hand Calculator activities for more student understanding and enjoyment of the lessons, rather than just "punching buttons".
- There is concern about what will happen to students who have had TOPS the previous year. Teachers asked what follow-up and sequencing will be provided for those students.

Another aspect of continuation will be teachers' reliance on other teachers in their buildings for help with TOPS lessons. There is evidence that teachers are helping one another, but in a limited way. A few teachers said they offered suggestions on how to teach specific lessons, answered teachers' questions, and shared techniques that they themselves had devised or learned. This is a low level of teacher-to-teacher support which will not be sufficient in and of itself to expand the program and may not even be enough to sustain the participation of new teachers who do not yet understand how to teach TOPS.

10. Expansion Prospects

One of the district's goals for TOPS was the development of a cadre of teachers who could act as change agents and expand the teaching of problem solving. This cadre of teachers played only a limited role (and much less than originally planned) in the process of expanding to new teachers. Nevertheless, the Coordinator and Demonstration Teacher have far exceeded expectations in the training of new teachers. One group of teachers has been trained, observed, and at present, is almost fully autonomous. They can call upon the Coordinator when needed but they are viewed as being able to function on their own. Having successfully launched one group of teachers, the site staff turned their attention to training two more groups and currently those groups have begun teaching TOPS under the staff guidance. About 10,000 students were receiving TOPS instruction by May, 1982, or about a quarter of the district's students in those grade levels.

The coordinating staff have also written lessons, prepared a teacher training program, and written a handbook describing training.

Based on these successful steps toward expansion, the district is currently working on ways to institutionalize TOPS in the district. In spite of critical budget problems and a teacher strike, the School Board has authorized continued support of TOPS, entirely from local funds, after the end of federally funded TOPS.

11. Overall Reaction

In an open-ended question on the questionnaire, teachers were asked to give an overall evaluation of TOPS. Their evaluations of TOPS were uniformly positive. They stated that TOPS participation had a beneficial effect on their teaching and a positive impact on their students.

In summary, teachers' ratings of the workshops, the lessons, and TOPS features were favorable. Teachers seem to have a practical and conceptual command over TOPS, and express an interest in continuing TOPS. Expansion is taking place more rapidly than planned, and the district is commited to continuing and expanding TOPS with local money.

This section is divided into two parts. The first part will present teachers' rating of TOPS impact regarding:

- TOPS effectiveness in improving students' thinking skills
- TOPS effectiveness in improving students' ability to do specific mathematical tasks
- TOPS value of teaching strategies

The second part will present test data from:

- The MANS Test
- Standardized achievement tests

1. Teachers' Ratings of TOPS Impact

TOPS effectiveness in improving students' thinking

	Much Improvement	Some Improvement	No Improvement
Analyzing Situations	52%	48%	—
Reasoning Logically	49%	51%	—
Evaluating Possible Answers	48%	52%	—
Reflecting Before Responding	48%	52%	—
Producing Multiple Answers	32%	64%	—

These ratings were somewhat lower than last year.

TOPS' effectiveness in improving students' ability to do specific mathematical tasks.

	Much Improvement	Some Improvement	No Improvement
Place Value	20%	71%	7%
Fractions	46%	12%	42%
Estimation	47%	37%	16%
Word Problems	28%	72%	
Decimals	20%	40%	40%
Mental Arithmetic	74%	26%	—

Ratings are slightly higher than last year.

Value of TOPS teaching strategies

	Helps A Lot	Helps A Little	Doesn't Help
Less pressure (no "wrong" answers, everyone can contribute)	78%	22%	—
Content (good problem situations, lesson plans)	72%	28%	—
Student responses (explaining "how to" and "why", many possible answers)	88%	12%	—
Hands-on material (Mini-computer, hand calculator, strings)	85%	10%	5%
Game atmosphere (no paper pencil, team play)	70%	25%	5%
Teacher questioning (thought provoking, open-ended, follow up to student responses)	77%	23%	—

Again this year, "Hands-on materials" and Student responses" received the highest ratings. Overall, ratings were similar to last year.

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2. Test Data

The MANS Test Data

To assess the effect of TOPS instruction on participating students, a version of the MANS Tests (Mathematics Applied to Novel Situations) was constructed specifically for TOPS and was administered to TOPS and non-TOPS classes.

The MANS Tests. The MANS Tests are short test scales originally designed to assess what are thought to be some of the underlying thinking skills of CSMP, the curriculum on which TOPS was based. They have been used for several years in the evaluation of CSMP in second through sixth grade. Since the thinking skills fostered by TOPS are similar to CSMP, an adaptation of the tests for TOPS evaluation seemed appropriate.

The MANS Tests used in this evaluation consisted of 20 separate tests, grouped into four categories: Estimation and Mental Arithmetic; Fractions and Decimals; Number Patterns and Relationships; and Production of Multiple Answers. (A description of the tests and their administration is given in Appendix B.) It is important to note that these tests do not refer to any TOPS lessons or contain any of the specific terminology of TOPS; indeed most were designed especially to present mathematical tasks which the students had not encountered previously. A specially trained tester followed a standardized script in introducing, one-at-a-time, the various tests.

The Sample. Twelve classes of seventh grade students were tested (6 TOPS and 6 non-TOPS classes). The seventh grade was thought to be the most appropriate grade level for comparing TOPS and Non-TOPS students' performance. One class from each of six veteran TOPS teachers was tested. One class from each of six comparison Non-TOPS teachers was also tested.

Selection of classes to be tested was made by the district staff. Non-TOPS classes were selected so that, in each case, classes were comparable in ability to TOPS classes and teachers' ability was judged comparable to the corresponding TOPS teachers.

For several reasons, TOPS classes could not be kept together from year-to-year. Hence the original evaluation plan, which called for the testing of TOPS students with two years of TOPS instruction, could not be followed. Five of the six classes were composed almost entirely of new-to-TOPS students.

Method of Analysis. For each class, a mean score was calculated for each MANS test. A class mean score was also calculated for each class on two independent measures: a. the district administered Reading Comprehension subtest of the California Achievement Test. b. a Figural Reasoning test, consisting of items in which students had to decide which one of four given figures was different from the other three. This was considered to be measure reasoning of a very different kind from that of TOPS or any other math program. (The mean scores for this new test were 7.9 for TOPS classes and 8.2 for Non-TOPS classes. The mean raw score across TOPS classes on the reading test was 19.0; for Non-TOPS classes it was 20.2.)

Thus, the classes were reasonably well matched in ability. An Analysis of Covariance procedure on class means was then used so that mean scores on the MANS tests were adjusted to take into account differences in ability among the classes as measured by reading and figural reasoning scores. (Appendix C presents class means for TOPS and non-TOPS classes).

Results. Table 1 shows adjusted mean scores for TOPS and non-TOPS classes. The tests have been grouped into categories of mathematical processes. The p-value of the comparison is also given, i.e., the probability that a difference that large between the two groups could have occurred by chance if there were truly " no differences" between the TOPS and non-TOPS classes. A p-value of .05 or less is often designated as statistically "significant" (i.e., would happen by chance only once in twenty times).

TABLE 1

SUMMARY DATA, MANS TESTS

SITE A

ADJUSTED MEAN SCORES

MANS CATEGORIES, TOPS AND NON-TOPS

	TOPS Classes	Non-TOPS Classes	P-Value
Estimation and Mental Arithmetic Includes two types of scales: Estimation requires the rapid deriving of approximate answers to problems, and Mental Arithmetic requires the exact answers to calculations amenable to non-algorithmic solution.[2]	35.6	31.5	.20
Fractions and Decimals Requires computation with fractions and decimals in a variety of novel applications.	28.1	23.6	.15
Representations and Patterns of Numbers Requires finding or applying a given pattern in sets of numbers.	39.0	33.1	.02
Elucidation Requires producing many correct answers to a given problem.	25.5	22.1	.15
Total MANS	128.3	118.4	.05

[1]Based on the t-test from the Analysis of Covariance with 8 degrees of freedom.

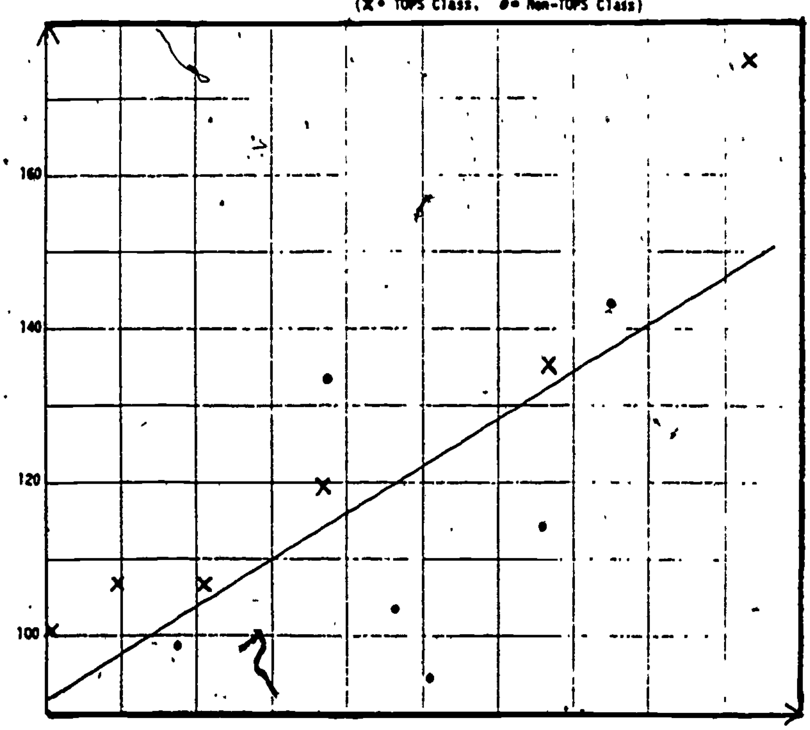
[2]A description of the tests in each category is given in Appendix B.

The table shows that TOPS classes had significantly higher Total MANS scores than the Non-TOPS classes (using the traditional .05 level of significance). They also had significantly higher scores in one category, <u>Representations and Number Patterns</u>. In the other three categories, although .05 significance was not obtained, the p-values of, at most, .20 are very suggestive (i.e., there is less than a one-in-five probability that these differences could have happened by chance).

Graphs of Class Means. Data from Table 1 are illustrated by the graph of Total MANS scores shown on the next page. Each class is plotted on the graph according to MANS score and ability score (where ability scores is a composite of reading and figural reasoning). An X is used for TOPS classes, a dot ( ) for non-TOPS classes.

A regression line has been drawn on the graph; this line represents the best linear prediction of MANS score from class ability scores. Classes which are represented above the line are performing better than expected based on their reading scores; classes below the line are performing worse than expected.

GRAPH OF CLASS MEANS
(X = TOPS Class, ● = Non-TOPS Class)



Composite Ability Score

Standardized Achievement Tests

In addition to showing problem solving ability on tests designed specifically to measure problem solving, differences between TOPS and non-TOPS classes were expected on the standardized achievement tests administered by the district each year. Therefore, achievement test scores (The California Achievement Test, administered Spring, 1982) for the seventh grade TOPS and non-TOPS classes which participated in the MANS testing were compared.

For the same groups of seventh grade classes, six TOPS classes and six non-TOPS classes, comparisons were made on the math subtests of the district administered California Achievement Test. An Analysis of Covariance was again performed on the class means, this time using only CAT Reading Comprehension as the covariate. Mean reading scores will differ somewhat from the MANS data because the exact composition of students present for testing differed from day-to-day. The mean reading score across TOPS classes was 18.7 and across Non-TOPS classes was 18.2.

Results. Table 2 shows the adjusted mean score for TOPS and non-TOPS classes. The p-value of the comparisons is also shown.

TABLE 2

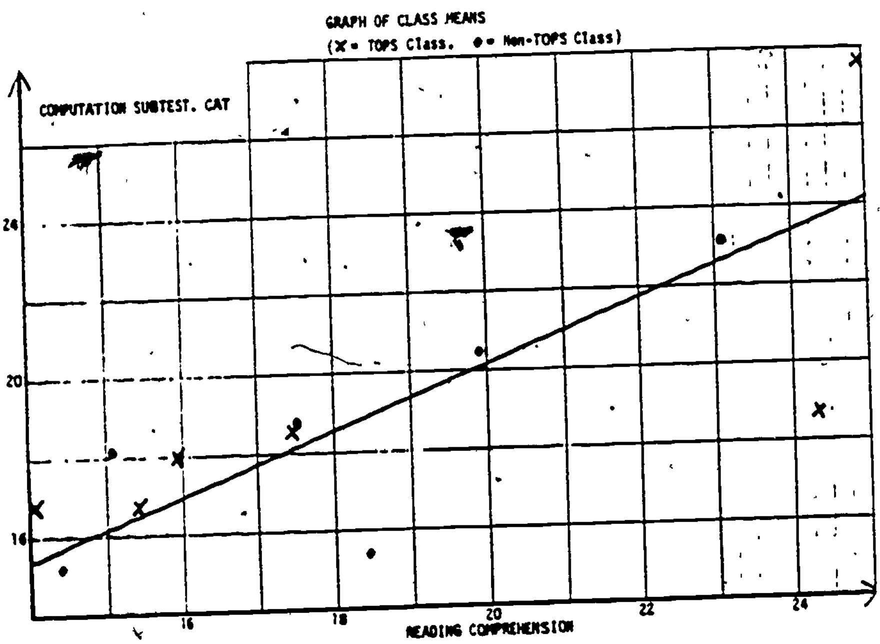
SUMMARY DATA, CALIFORNIA ACHIEVEMENT TESTS, SITE A
ADJUSTED CLASS MEANS

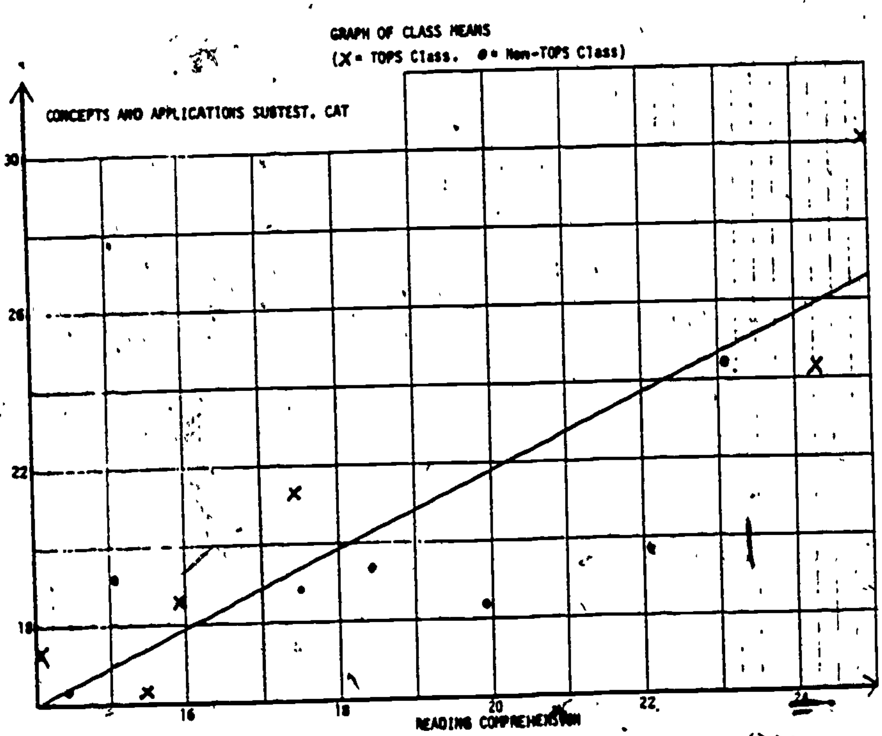
	TOPS Classes	Non-TOPS Classes	p-Value[1]
Mathematics Computation	19.3	18.6	-
Mathematics Concepts and Applications	21.3	19.4	.20
Total Mathematics	40.5	38.1	.35

[1]Based on the t-test from the Analysis of Covariance with 9 degrees of freedom. Where the p-value is not less than .5 (a one-in-two chance) a dash (-) appears in the table.

results were not significant at the .05 level.

Graphs of Class Means. Graphs of class means, like those of the previous section, are shown below for the two math subtests of the CAT. It can be seen that CAT Math scores are better predicted from Reading scores than were the MANS scores. Although inspection of the graphs shows TOPS classes do better generally, the pattern of results is too irregular to support a claim of superiority for TOPS classes, i.e., suggestive but not conclusive.





Data in this section were collected by means of a questionnaire mailed to Site B TOPS teachers at the end of Year II. Seventeen teachers returned the questionnaire; four were new to the project this year (two replaced Year I TOPS teachers who left the program) the rest were teachers who had taught TOPS during Year I.

1. Background and Experience

During Year I, a full-time Coordinator, who had a Bachelor's degree in mathematics and experience as a school and central office administrator directed the project at Site B. He continued that supervision until the last months of Year II. Two part-time Demonstration Teachers assisted during Year I; one had an advanced degree in mathematics and was a high school mathematics teacher, the other had experience as a supervisor. In Year II, both were replaced by a full time Demonstration Teacher who had both mathematics experience and supervisory/administrative experience.

In the tables which follow, data describing the teachers' background and experience is presented.

Background and Experience

Number of Years Teaching

1st year	0%
2 - 5 years	12%
6 - 10 years	29%
10 - 20 years	47%
20 plus years	12%

Highest Academic Status Attained

Bachelor's	12%	Bachelor's Plus	18%	Master's	35%	Master's Plus	35%

College Preparation

Elementary education major with no math methods courses	Elementary education with 1 or 2 math methods courses	Another major with Concentration in some math courses	Concentration in mathematics
18%	59%	18%	5%

The majority of TOPS teachers tend to be experienced teachers, have received advanced degrees, and their college background is typically an elementary education major with 1 or 2 math methods courses.

2. Teaching Schedule

More than half of the seventeen responding teachers taught math to only one or two classes per day. Less than half (40%) taught at junior high school; the others taught at elementary schools.

"Is TOPS instruction usually for?"

A few minutes at a time, but not every day	30%
A few minutes at a time each day	10%
A full math period each week	24%
Other	36%

These data illustrate the variety of implementation strategies TOPS teachers used in year II. It is worth noting that only ten percent of teachers reported teaching TOPS for a few minutes each day as newly mandated half way through the project.

3. TOPS Teacher Training

At the first series of workshops, 1980 - 1981, a general introduction to problem solving, as defined by the TOPS staff, was presented and that was

Strengths and Weaknesses of the Workshops. According to teachers, strengths of the workshops were:

- o Exchanging ideas.
- o Learning how to use the materials.
- o Learning a variety of problem-solving techniques.
- o Gaining an understanding of the application of mathematics theory through the TOPS activities.
- o More "focused" this year (one teacher)

and weaknesses of the workshops were:

- o Not learning how to do Detective Stories.
- o Needing a more in-depth introduction, i.e., not being thrown into teaching the activities so quickly.
- o Not spending enough time explaining the materials and their relations to problem solving.

Strengths and Weaknesses of Coordinator Activities. According to TOPS teachers, the strength of the Coordinator activities was the dual role of teaching and demonstrating followed by observing and offering suggestions. The weakness cited was that too much time elapsed between one Coordinator visit and another.

Rating Coordinator Activities

"If a Coordinator were available next year, what activities would you like to see emphasized?"

	very helpful	somewhat helpful	not usually helpful
Conducting demonstration classes	94%	6%	
Reviewing mathematical content	60%	30%	10%
Planning future lessons	53%	27%	20%
Discussing general problem solving strategies	87%	13%	
Critiquing lessons you taught	64%	18%	18%
Explaining the goals of an individual lesson	45%	45%	10%
Suggesting classroom management procedures	33%	66%	
Classroom visits in general	73%	27%	

followed by activities designed to familiarize teachers with the materials and procedures for the five TOPS strands, as well as to help teachers understand the mathematics embodied in the lessons.

Initially, this format was to be repeated at each succeeding workshop. However, by the time the August, 1981 workshop was held, the substantive changes in the project, mandated by the project officer, necessitated a refocusing of the workshop. As a result, a significant part of the workshophad to be devoted to explaining the personnel, schedule, and curriculum changes brought about by the mandate. Therefore, the focus of the August, 1981 workshop and subsequent workshops shifted from practice and growing expertise with the TOPS materials, to introductions to a more varied set of curriculum materials, some of which were TOPS materials (the Mini-computer boards, the TOPS sourcebook, etc.); some were locally produced problems, and some were commercial materials.

Distribution of Workshop Topics and Ratings of Effectiveness. (Percentages do not always total 100% because of teachers' responding patterns.)

	Percent of time	effective	somewhat effective	not effective
Overview of the program's philosophy and goals	14%	47%	47%	6%
Discussion/presentation of math content by trainer	25%	60%	33%	6%
Demonstration/discussion by trainer of specific lessons	32%	66%	33%	-
Practice by participants teaching various lessons	29%	75%	19%	6%

Thus, if a Coordinator or Demonstration Teacher were available next year, almost all teachers would like demonstrations to be a first priority. Planning future lessons and discussing general problem solving strategies also were frequently cited by teachers.

4. Distribution of TOPS Lessons

Site B's logs were designed to specify the lesson objectives and record the problem solving strategy chosen from a variety of strategies. Some of the teachers' strategies were traditional problem solving activities and didn't represent the specific TOPS focus; in other instances it couldn't be determined which TOPS materials or strategies had been used or how the lesson had been taught. Therefore, logs were not relied on for any data other than a count of the number of times a specific, unambiguous reference to a TOPS activity was made.

Analysis of the logs showed the following distribution of TOPS lessons.

TOPS Activity

	This years teachers	Last years teachers
String Games	38%	34%
Arrows	15%	15%
Mini-computer	29%	27%
Hand Calculator	13%	20%
Detective Stories	5%	3%
Geometry	-%	1%

This distribution of lessons ~~across~~ across the strands is roughly proportional to last year's distribution. However, far fewer identifiable TOPS lessons were recorded this year compared to last year; the average number of identifiable TOPS activities per teacher was only about six. The decrease in numbers reflects the site's decision to de-emphasize teaching specific TOPS lessons and use traditional forms of problem solving to teach mathematics topics found in the text books.

5. Teachers' Assessments of TOPS Features

The statements below were generated from negative comments one or more teachers made during observations and interviews conducted in Spring, 1981. (Responses do not always total 100% because of the pattern of teacher responses.)

	Strongly Agree	Agree	Disagree	Strongly Disagree
Teaching TOPS takes too much preparation time.	___	12%	71%	18%
TOPS ideas can be applied in situations outside TOPS classrooms.	35%	59%	___	___
TOPS does not conflict with our school's math goals.	47%	41%	12%	___
TOPS does not contain enough drill.	___	41%	35%	18%
Tests should be included as part of the TOPS materials.	6%	41%	29%	6%
TOPS is not useful in any other context.	___	___	47%	53%
TOPS goals are clear.	24%	53%	18%	___
TOPS does not help me learn more about my students	___	___	71%	29%
The game aspect of TOPS lessens its value.	6%	18%	47%	29%
Students who have had TOPS this year should continue with TOPS next year.	44%	56%	___	___

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More teachers gave favorable ratings this year than last year, and the ratings reflect generally positive attitudes. There were three negative statements agreed to by between a quarter and a half of the teachers; these three dealt with the need for more drill, more tests, and the game aspect of TOPS.

However, interview and questionnaire data may explain these three relatively negative sets of responses. While teachers expressed satisfaction with TOPS activities and materials, they also expressed concern about spending time on TOPS at the expense of "local objectives". To many teachers, the text was a set of local objectives to be covered as comprehensively as possible. Teaching TOPS activities was viewed as conflicting in time and priorities with the local objectives. Thus, while many teachers said they agreed with TOPS goals and could see the benefit of TOPS to students' performance they also had doubts about the wisdom of not teaching the text -- and risking lower test scores. Hence the perceived need for more tests, more drill, and fewer games.

6. Classroom Implementation Choices

Since the site elected to change its TOPS program for Year II, the TOPS Sourcebook, a set of lessons developed for Year I, was not used as frequently, or in the same way, as it had been used in Year I. Electing an approach to problem solving which attempted to integrate the textbook and with many types of materials, the site left use of the Sourcebook to teachers' discretion.

Thus, teachers were asked how frequently they used 1) the district's text to teach problem solving, 2) the TOPS Sourcebook, 3) the local problem-solving activity sheets and 4) other commercially available materials.

"In teaching TOPS, how frequently do you use each of the following?"

	always	almost always	often	rarely	never
the text book	38%	56%			6%
the TOPS Sourcebook	6%	24%	46%	18%	6%
"I Love TOPS" locally produced activities	12%	24%	40%	24%	
Other commercially available products (please specify) ________	6%	29%	41%	24%	
Materials made by (please specify) ________	7%	7%	36%	21%	29%

The most frequently used problem-solving material was the local textbook with ninety four-percent of the teachers using it "always" or "almost always". In contrast, only 30% of the teachers used the "official" TOPS Sourcebook that often. The local activities and commercial products were used with about the same frequency as the Sourcebook.

Teachers' comments about teaching TOPS daily, as well as their personal definitions of problem solving, highlight the disparity which exists among teachers at Site B. One teacher said she made up her own activities based on ideas in the Sourcebook. She teaches TOPS once a week for a full math period

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and then twice a week devotes five minutes of the math period to word problems. Another group of teachers, four in the same school, reported different implementation strategies. One reported distributing the locally prepared checklist of problem solving strategies, which forms the basis of the teacher logs, to students. He advised them to apply the strategies to word problems and other math problems. The Mini-computer and String Game were never used in that classroom, and emphasis on the thinking skills was restricted to about ten minutes each week. A second teacher used the locally produced activities in conjunction with the text because the two complemented one another, rarely used the Hand Calculator but did use the Mini-computer and the String Game. Another teacher reported using the text as the principal source of problem solving activities, and the last teacher used all resources available including commercial problem solving kits.

A teacher in another school used Strings to discuss sets, and commented that while it was hard to see TOPS' application to the regular curriculum, it was a "colorful review". Another teacher also reported she didn't use the Sourcebook extensively but instead "pushed mechanical techniques".

These comments typify comments made by other teachers, i.e., some teach TOPS using the Sourcebook selectively, some teach TOPS using a wide variety of materials, some teach their own version of problem solving and use their own strategies.

Teachers who did use the TOPS Sourcebook were asked to rate its effectiveness in teaching problem solving, its appropriateness for students, its match a) with the local textbook, b) with local goals, and c) with the teachers' definition of problem solving. Ratings for three out of the five categories were "average" to "excellent". Twenty-one percent of the teachers judged that lesson appropriateness was below average compared to other materials, and fourteen percent judged it below average as a match with the local textbook.

The questionnaire asked teachers if the Sourcebook needed revision, since it was anticipated teachers might not want to use it because of some major deficiency. In fact, a majority of the teachers (71%) recommended that no changes be made.

Teachers who recommended changes made four types of suggestions:

- Add flow charts and schematic diagrams which had been developed during the June '81 planning seminar.
- Explain every step of the demonstration problems and don't take for granted that the teacher knows how to do the problems.
- Reference each lesson to the standard curriculum.
- Include more Arrow lessons.

7. <u>Changes In Teaching</u>

One aspect of implementing TOPS is the changes teachers made from Year I to Year II. Teachers mentioned several different changes from one year to another. Unlike Site A teachers who reported using questioning strategies more and encouraging students' analysis, Site B teachers discussed the Coordinator visits, improvement in their teaching, and integration with the regular text.

Two teachers said that Year II was not as productive for them because the Coordinator schedule was not as helpful as last year. Three teachers said TOPS was easier to teach this year; having learned the problem-solving techniques they were able to practice those techniques this year. Integration of problem-solving techniques with the standard curriculum was viewed as a positive step by teachers, but one teacher thought there was confusion about how and when to integrate problem solving with the text.

One teacher reported using a variety of strategies and materials as a result of TOPS, another reported an increased awareness of problem solving, another agreed with this and reported further that it was a direct result of the teacher training provided by CEMREL staff during the workshops. However, other teachers mentioned that what they had learned through TOPS was not generalizable since there were local goals and test scores to worry about.

Teachers were also asked what changes they had made in their regular math class as a result of TOPS. Teachers replied (in about equal numbers) that:

- They didn't change since TOPS was so similar to their own teaching style.
- They had made no major change since TOPS doesn't fit the school district's own curriculum and takes away from (regular) lesson planning.
- They had added a variety of strategies (looking for solutions, analyzing the problem); had adopted a more open-ended questioning style, concentrated on training processes and not on answers, used a higher level questioning strategy and used basic math skills as a means of solving problems, not an end in themselves.

8. Teachers' Views on Continuation

Ninety-four percent of all teachers said they would be capable of teaching TOPS next year and all teachers said they would choose to teach TOPS.

While many teachers indicated they would make no changes in the way they taught TOPS, three said they would prefer to do it one day a week or every other week. Four teachers said they would try to integrate it more fully with the curriculum, one would do more pre-planning and one would pay more attention to lower ability students.

Asked what help they would need if they taught TOPS next year, two teachers reported they would need no help, while others reported they would need support (5), supplies (3), ideas (3), and motivation (2).

More than half of TOPS teachers said that at least 75% of the math teachers at their grade level could do an effective job with TOPS, and about a quarter said that 50% to 75% could do so. All teachers would like to see TOPS used in their schools.

Teachers cited seven different problems they had faced in the past including:

- Adjusting to Coordinator's plans and schedule changes.
- Understanding the program and how to use the materials.
- Relating the materials and activities to the curriculum.
- Arranging the schedule in order to use the materials effectively.
- Thinking of mathematics in terms of logical thinking and not as computation.
- Changing their teaching style to accommodate to TOPS.
- Gaining confidence with TOPS.

Asked what problems new-to-TOPS teachers would face, the same issues were stated again. Teachers who had taught TOPS said new teachers might experience difficulty because:

- There is not enough time for demonstration lessons, and time and practice are necessary if teachers are going to be successful with the project.
- Many teachers do not have a strong enough mathematics background. They need time to become familiar with the materials and need help allocating time between mathematics as a reasoning activity and mathematics as a computation activity.
- Other teachers perceive the district's curriculum as fixed, as not accommodating TOPS goals, and therefore are unwilling or unable to change the curriculum and their approach to the curriculum.

In the course of implementing any new curriculum there are persistent problems which teachers face. For teachers at this site, problems fell into four categories:

- o Coordinator visits were not frequent enough for teachers to maintain momentum.
- o Teachers found it difficult to sustain their own or their students' interest and motivation.
- o Time was needed to learn the activities and plan ways to present them to the class.
- o Integrating the activities into the curriculum required time, skill and understanding.

For the Coordinators, persistent issues at the site include a mutually agreed upon conceptual and operational definition of problem solving, time to continue training teachers to use problem solving since there are too few trained to make an impact on the entire district, and a way to integrate problem solving with the local text.

9. Expansion Prospects

One of the district's goals for TOPS was the development of a cadre of teachers who could act as change agents and expand the teaching of problem solving.

The prospects for expansion are guarded. Like Site A teachers TOPS teachers won't be able to carry the entire expansion effort on their own. Some of the teachers from Year I who might have been able to were not TOPS teachers in Year II, or were confused by the second year refocusing of the project. Too few were in the project both years and they were not adequately prepared to be a major force for expansion.

While the majority of teachers said they will use TOPS materials next year, they also indicated that expansion within their schools and throughout the district must be directed by principals or other administrators. Teachers see themselves as having neither the time nor the influence to effect TOPS expansion. Unlike Site A where plans for continued expansion and commitments for future funding have been made, Site B's plans are not explicit at this time.

However, the Coordinator and the Demonstration Teacher said the district does have plans, including the part-time assistance of a Year I Demonstration Teacher and the sponsorship of a course through the district's inservice agency.

Asked about expansion, principals said they had no plans for concrete plans or activities to promote the spread of TOPS in their building. One said current TOPS teachers would have to go it alone; the other looked to his TOPS teachers to spread TOPS to other classrooms. This is interesting because teachers who were interviewed stated that the responsibility for TOPS expansion must come from principals, central administrators, or both, if expansion is to occur.

The logistics of expansion are a problem. Principals are reluctant to hire several substitutes to cover classes so that current or future teachers can attend workshops. Consequently, expansion plans, if any, are compromised by the constraints of teacher training logistics.

10. Overall Reactions of TOPS Participants

In an open-ended question on the questionnaire, teachers were asked to give an overall evaluation of TOPS. Teachers said that TOPS was an excellent program and that they enjoyed participating. Several teachers said they will adopt its materials and techniques no matter what the district decides to do because they appreciated its impact on students' thinking and found it helpful for their own development. One teacher said it was an excellent way to meet NCTM's goal of teaching problem solving. The only negative comment was that it was difficult to find the time to teach TOPS activities and also teach the district's math curriculum.

In summary, teachers' ratings of the workshops, the lessons, and TOPS features were positive. However, some teachers are concerned about the match between TOPS goals and local goals. For many teachers TOPS in service and teaching was their first introduction to conceptually oriented (as opposed to computationally oriented) mathematics. Those teachers are only beginning to gain a practical and conceptual command over TOPS. Expansion is taking place less rapidly than planned, and the district is commited to continuing and expanding TOPS at a much slower pace and in a less systematic way than at Site A.

This section is divided into two parts. The first part will present teachers' rating of TOPS impact regarding:

- o TOPS effectiveness in improving students' thinking skills
- o TOPS effectiveness in improving students' ability to do specific mathematical tasks
- o TOPS value for teaching strategies

The second part will present students' standardized achievement test data.

Teachers' Ratings of TOPS Impact

TOPS effectiveness in improving students' thinking skills.

	Much Improvement	Some Improvement	No Improvement	No Answer
Analyzing Situations	38%	56%	-	6%
Reasoning Logically	53%	47%	-	
Evaluating Possible Answers	35%	59%	6%	
Reflecting Before Responding	29%	41%	24%	6%
Producing Multiple Answers	24%	58%	12%	6%

Teacher ratings were lower for all categories this year.

TOPS effectivess in improving students' ability to do specific mathematical tasks.

	Much Improvement	Some Improvement	No Improvement
Place Value	38%	50%	12%
Fractions	8%	50%	42%
Estimation	14%	57%	29%
Word Problems	50%	50%	
Decimals	31%	46%	23%
Mental Arithmetic	56%	44%	

Fewer teachers this year thought "Much Improvement" had occurred.

TOPS value for teaching strategies.

	Helps A Lot	Helps A Little	Doesn't Help
Less pressure (no "wrong answers", everyone can contribute).	94%	6%	
Content (good problem situations, lesson plans)	70%	24%	6%
Student reponses (explaining "how to" and "why", many possible answers)	65%	35%	
Hands-on material (Minicomputer, hand calculator, strings)	88%	12%	
Game atmosphere (no paper pencil, team play)	88%	12%	
Teacher questioning (thought provoking, open-ended, follow up to student responses)	82%	18%	

This year, teachers' rating were slightly higher than last year's ratings for all but two categories -- content and student responses.

Standardized Test Data, Fourth Grade Comparisons

The primary goal of the TOPS staff and most of the teachers was to improve students' ability to solve word problems, in order to improve performance on the Concepts and Applications sub-test of the California Achievement Test which is routinely administered by the district. Given that goal, and the differences in the way TOPS was implemented from one classroom to another, it seemed appropriate not to administer MANS Tests, but instead, to analyze achievement test data.

The Sample. Test data from seventeen classes of fourth grade students, tested in May, 1982, were analyzed (9 TOPS and 8 non-TOPS). Fourth grade was selected because the largest number of TOPS classes were to be found at Grade 4. The TOPS classes tested were chosen by the site staff on the basis of their representativeness; most of the students were in their first year of TOPS. Non-TOPS classes were also selected by the site staff, the primary criterion for their selection being similarity to TOPS classes in student and teacher ability.

Method of analysis. For each class a mean score was calculated for each Mathematics test and for the Total Reading test of the California Achievement Test, administered in the Spring of 1981. An Analysis of Covariance procedure was then used so that mean mathematics scores were adjusted to take into account the differences in class ability, as measured by reading scores. (Appendix D presents TOPS and non-TOPS class means.) The mean Total Reading score (scaled score) for the nine TOPS classes was 427.6 vs. 425.4 for the eight non-TOPS classes; thus mathematics scores were statistically adjusted (downward for TOPS, upwards for Non-TOPS) to reflect this difference.

Results. Table 3 shows TOPS and non-TOPS adjusted mean scores. The p-value of the comparison is also given, i.e. the likelihood of a difference of that size happening by chance.

TABLE 3
SUMMARY DATA, CALIFORNIA ACHIEVEMENT TEST
FOURTH GRADE CLASSES, SITE B, 1982

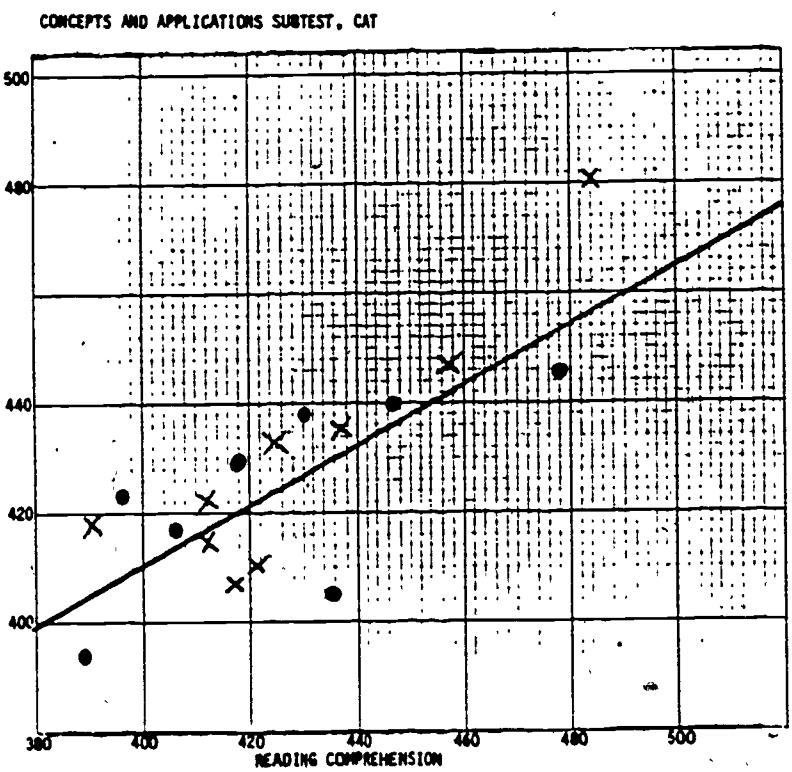
	TOPS Classes	Non-TOPS Classes	p-Value[1]
Mathematics Computation	420.7	416.6	-
Mathematics Concepts and Applications	430.7	425.2	.35
Mathematics Total	424.9	420.0	.35

[1] Based on the t-test for the Analysis of Covariance with 14 degrees of freedom. A dash (-) indicates the difference was not significant at even the .50 level (one chance in two).

Although TOPS classes had higher scores on both subtests, the differences were not statistically significant.

Graphs of Class Means. Data from Table 3 are amplified in the graph shown below, where Math Concepts and Applications class means are presented. The Math score for each class is plotted against Reading score. A line has been drawn to show the best linear prediction of Math scores for given Reading scores. It can be seen that Reading is a fairly good predictor of Math and that there is very little advantage for the TOPS classes.

GRAPH OF CLASS MEANS
FOURTH GRADE CLASSES
(X = TOPS Class, ● = Non-TOPS Class)



Standardized Achievement Tests, Second year TOPS Students vs. Non-TOPS Students. There is also a group of fifth grade students at site B who have had TOPS for two years. Although those students did not move in intact classes from one TOPS teacher to another, it was possible to locate groups of those students, and to record their Math scores from the 1982 CAT. In contrast to the TOPS students (who were in small and large groups in their classes) the non-TOPS "comparison" group was composed of intact classes selected by the Coordinator because those classes were similar in ability to classes in which TOPS students were found.

It was also possible to record the 1981 CAT Reading score for these students and this was used as a covariate in an Analysis of Covariance, this time with students as the units of analysis. Table 4 shows the adjusted means in Mathematics for both groups of students and the resulting p-value of the test of significance. The mean 1981 Reading scores were 431.1 for TOPS students vs. 444.1 for Non-TOPS.

Table 4

Summary Data, Second Year TOPS Comparison
Fifth Grade, Site B, 1982

TOPS and Non-TOPS Students
1980-1981/ 1981-1982

	TOPS Students	Non-TOPS Students	p-Value[1]
CAT Mathematics Computation, 1982	469.9	462.6	.30
Mathematics Concepts and Applications, 1982	470.4	461.4	.10
Mathematics Total, 1982	468.6	460.5	.10

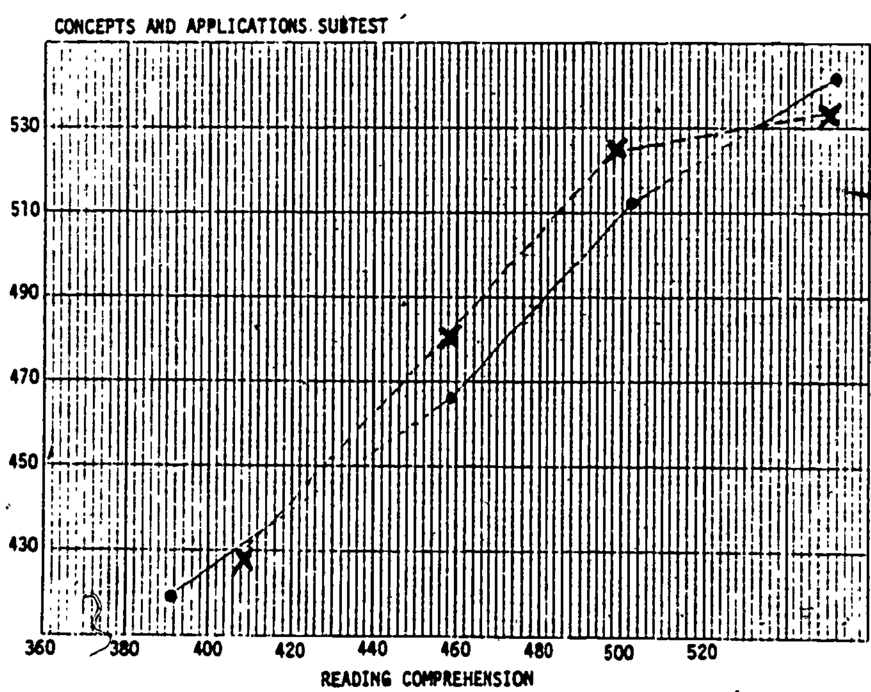
[1]Based on the Analysis of Covariance t-test with 211 degrees of freedom.

55

The differences, though favoring TOPS students were not significant at the usual .05 level, but were significant at the .10 level (i.e. a one-in-ten likelihood this difference occurred by chance).

One should bear in mind that this analysis had to done at the student level, yielding more liberal results than the more usual class level analysis. Rather than grouping students into classes, the graph below shows the results when students are grouped according to reading ability. Thus all students with Reading percentile rank between 75 and 99 were grouped together and average Reading and average Math scores computed for that group and plotted and similarly for the other quartiles. This yielded graph points for TOPS and for non-TOPS students for each quartile. Because TOPS schools generally were selected on the basis of low achievement scores, these points are always based on progressively more students in the lower quartiles (e.g. for TOPS students, 10, 20, 24, and 48 students respectively.

TOPS VS NON-TOPS QUARTILE MEANS
FIFTH GRADE
(X = TOPS Class, • = Non-TOPS Class)



It can be seen that it is in the middle quartiles (i.e. percentile rank in reading from 25-75) that the TOPS students do relatively best.

RECOMMENDATIONS

The data show that TOPS was favorably received by the majority of participating staff and had some effect on participating students. The favorable reactions speak well for both CEMREL staff and the local districts' staff. Their work with TOPS was clearly a key factor in teachers' evaluations.

The next question is "What do potential adopters need to consider given TOPS history at Site A and Site B?

TOPS history points to several major conditions (in our view) which are necessary for success. To the extent that present sites are meeting these conditions they will be successful; future adopters will need to review these conditions with an eye toward their own situation.

o Supervisors and teachers should know enough mathematics to understand the mathematical processes in TOPS activities and know how the lessons lead to students' understanding.

o If teachers have sufficient mathematics background to understand and teach TOPS, they should be able to play the major role in implementing TOPS in their classroosm. Coordinators would then act to analyize, review, and critique.

o If teachers do not have sufficient mathematics background, the trainer will have to play the major role in demonstrating and discussing lessons; the mathematical processes embodied in the lessons will need to be explained, and the goal of the lessons specified. For these teachers it would be a mistake to assume that the lessons are self-explanatory <u>but</u> it would be equally undesirable to teach mathematics first and then teach TOPS activities.

Throughout the year the trainer may also need to play a major role in the classroom, first demonstrating lessons and then critiqueing teachers' lessons.

o Both groups of teachers, the mathematically knowledgeable and those less so, should remember to begin teaching both TOPS activities and traditional problem solving methods at the same time may confuse students more than help them. Once solidly in place, TOPS may be a springboard for introducing traditional problem solving, but given TOPS' specific point of view at the start, the best way to maximize its effect is to learn and practice TOPS lessons.

o Once the decision is made to adopt TOPS, a district must provide sufficient training initially, and follow up for teachers. If a long term impact on students is desired, then a large enough cadre of teachers should be trained so that TOPS can be implemented at many grade levels and year-to-year scheduling can be simplified. Training specialist teachers, who teach more than one grade level, is advantageous for long term effects. Training specialist teachers is also a more cost effective way of reaching the largest number of students in one day, which maximizes the training investment.

Teachers need to be told the district is commited to TOPS. Since the lessons might not seem to directly translate to achievement test success, the district needs to communicate a willingness to bide its time and to delay a final weighing of the evidence until a comprehensive implementation has occurred. Otherwise, teachers are likely to return to what they perceive to be the district's "real" goals.

There are several caveats for potential adopters. Learning the TOPS activities may frustrate the teachers at first, and they should be encouraged to persist. Coordinators are the key in this respect. They will need to monitor how often and how well TOPS is taught. Then, the evaluation of TOPS will need to be carefully considered. "Traditional" achievement tests may not be sensitive to TOPS instruction and districts should be aware of the difficulties inherent in assessing problem solving.

Districts whose goals match TOPS goals, and who have the resources to train teachers and monitor their TOPS implementation, should find TOPS makes a positive contribution to teachers and students.

Appendix A

Questionnaires

TOPS TEACHER QUESTIONNAIRE

School: ____________________

I. Background

1. How many years have you taught?

☐ 1st year ☐ 2-5 years ☐ 6-10 years ☐ 10-20 years ☐ 20 plus years

2. Highest academic status attained:

Course work leading to a Bachelor's	Bachelor's	Bachelor's plus	Master's	Master's plus
☐	☐	☐	☐	☐

3. In college, did you elect:

Elementary Education Major with no math methods courses	Elementary Education with 1 or 2 math methods courses	Another major with some math courses	Concentration in mathematics
☐	☐	☐	☐

4. What grade level(s) are you teaching math to this year? __________

5. How many classes do you teach math to each day? __________

6. How many years have you taught math at this grade level? __________

7. What other grade levels, if any, have you taught math? __________

8. On an average, how many minutes does your class spend on math each day? __________

9. Did you volunteer ☐ or were you asked to participate ☐ in TOPS?

10. When did you begin teaching TOPS?

During the previous school year.	At the beginning of present school year.	Within the last few months.
☐	☐	☐

II. Teaching TOPS

1. Since you started teaching TOPS, what percent of math time has been spent on TOPS instruction? __________

Is it usually for: a few minutes at a time, but not every day ☐

a few minutes at a time each day ☐

a full math period each week ☐

2. If you are a second year teacher, briefly compare teaching TOPS this year to teaching TOPS last year.

3. Check whether you strongly agre agree, disagree, or strongly disagree with the following statements:

	Strongly Agree	Agree	Disagree	Strongly Disagree
Teaching TOPS takes too much preparation time.	___	___	___	___
TOPS ideas can be applied in situations outside TOPS classrooms.	___	___	___	___
TOPS does not conflict with our school's math goals.	___	___	___	___
TOPS does not contain enough drill.	___	___	___	___
Tests should be included as part of the TOPS materials.	___	___	___	___
TOPS is not useful in any other context.	___	___	___	___
TOPS goals are clear.	___	___	___	___
TOPS does not help me learn more about my students.	___	___	___	___
The game aspect of TOPS lessens its value.	___	___	___	___
Students who have had TOPS this year should continue with TOPS next year.	___	___	___	___

4. What changes, if any, have you made in the way you teach or what you teach during your regular math class? (state briefly)

III. Continuation

1. As a result of your present TOPS experience, if you had the TOPS materials but the coordinator was unavailable

   a) would you be capable of continuing to teach TOPS? Yes ☐ No ☐

   b) would you choose to teach TOPS next year? Yes ☐ No ☐

   If yes, what changes, if any, would you make?

   If no, why not?

2. If you did teach TOPS next year, what help, if any, would you need?

3. About what percent of teachers now teaching Math at your grade level(s) could do an effective job with TOPS? ________

4. Would you like to see TOPS used in other classes in your school?

   No ☐ Yes, at all grades ☐ Only in grades ____ ☐

5. What is the biggest problem new-to-TOPS teachers face in teaching TOPS? (comment briefly)

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IV. Workshops and Coordinator Activities

1. During the workshops what percent of the time was spent on each topic and how effective was the presentation?

	Percent of time			
Overview of the program's philosophy and goals	______	effective	somewhat effective	not effective
Discussion/presentation of math content by trainer	______	effective	somewhat effective	not effective
Demonstration/discussion by trainer of specific lessons	______	effective	somewhat effective	not effective
Practice by participants of teaching various lessons	______	effective	somewhat effective	not effective

2. What were the strengths and weaknesses

a) of the workshops

b) of other coordinator activities (i.e., individual contacts, meetings)

3. If a coordinator were available next year, what activities would you like to see emphasized? (check as many as apply and rate the helpfulness of each)

		very helpful	somewhat helpful	not usually helpful
Conducting demonstration classes	______			
Reviewing mathematical content	______			
Planning future lessons	______			
Discussing general problem solving strategies	______			
Critiquing lessons you taught	______			
Explaining the goals of an individual lesson	______			
Suggesting classroom management procedures	______			
Classroom visits in general	______			

4. What were the most persistent problems in implementing the program this year?

V. Benefit to Students

1. How well does TOPS improve students' ability to do problems in:

(check one)	much improvement	some improvement	no improvement
place value	___	___	___
fractions	___	___	___
estimation	___	___	___
word problems	___	___	___
decimals	___	___	___
mental arithmetic	___	___	___

2. What aspects of TOPS make it beneficial to students:

(check one)

	Helps a lot	Helps a little	Doesn't help
Less pressure (no "wrong" answers, everyone can contribute)	___	___	___
Content (good problem situations, lesson plans)	___	___	___
Student responses (explaining "how to" and "why", many possible answers)	___	___	___
Hands-on material (Mini-computer, hand calculator, strings)	___	___	___
Game atmosphere (no paper pencil, team play)	___	___	___
Teacher questionning (thought provoking, open-ended, follow up to student responses)	___	___	___

3. How well does TOPS improve students' thinking skills in:

(check one)

	much improvement	some improvement	no improvement
reasoning logically	___	___	___
evaluating possible answers	___	___	___
reflecting before responding	___	___	___
producing multiple alternatives	___	___	___
analyzing situations	___	___	___

Site A only

VI. TOPS Materials

1. Rate these TOPS materials-- as high or low on:

	String Game	Language of Arrows	Hand Calculator	Mini-Computer	Detective Stories
Can be used effectively by a teacher					
Promoting student growth in problem-solving skills					
Promoting positive student attitude toward problem-solving					
Student enjoyment					
Overall benefit to students compared to the math period it replaced					

2. What changes, if any, would you recommend be made in any of the TOPS materials.

VII. 1. What assistance have you provided to other teachers in your school, if any, who have recently started TOPS?

VIII. 1. Overall, what is your view of the TOPS program?

VI. TOPS Materials

1. In teaching TOPS, how frequently do you use each of the following:

	always	almost always	often	rarely	never
the text book					
the TOPS Sourcebook (orange TOPS book)					
"I Love TOPS" Activities					
Other commercially available products (please specify) ________					
Materials made by ________					

2. Are there any changes you would recommend be made in the TOPS sourcebook?

   Yes ☐ No ☐

   If yes, what changes?

3. If you usually use the TOPS sourcebook, please compare it to other materials for:

	Poor	Below Average	Average	Above Average	Excellent
Ease in Teaching Problem Solving					
Appropriateness of Lessons for Students					
Match with Local Textbooks					
Match with Local Goals					
Match with your Own Definition of Problem Solving					

VII. 1. Overall, what is your view of the TOPS program?

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"Overall, what is your view of TOPS?"

Site A

It would make a great elective.

I'm not certain that a loss of class periods is more beneficial than math. I did not accomplish what I hoped to this year.

Very good.

I like TOPS. I had a bad start last year. Now I expect to get into the program.

It appears to promote problem solving techniques and can be used in conjunction with any math program.

Excellent. Problem solving skills can be developed using it.

I believe I've seen improvement of thinking skills and it's spilled over into classroom activities.

A challenging program if you can attune students to it. It is difficult to get them to see it is math.

I compared students' scores and some went up and some went down.

It is a rewarding experience.

It is an excellent program to get students to think. They're all eager to be involved.

It's great. It's too bad this is necessary beyond the primary grades.

Terrific. It affects the cognitive domain of students. It is a much needed program.

It is excellent.

I'd like to see a follow-up for teachers to show TOPS supervisors how a lesson they would teach could be put in a TOPS format. All teaching could be done that way with careful planning.

I'm impressed. I use it twice a week. The style, questioning and reasoning together, works well. It spins off in the teaching of other math materials.

A great first step to improving math abilities. We should not stop here.

Overall growth at the end of the year in some areas.

It has not been a cure-all. I'm not totally satisfied with it, maybe because I used it in only one class.

It is excellent in developing problem solving in all areas of math. It has made a difference to my attitude and approach in teaching math.

Overall, well done and good materials.

Essentially beneficial.

Great. It's too bad this kind of analysis training is necessary beyond the primary level.

It's good for students' reasoning skills. There is too much emphasis on test scores. Reasoning is being neglected and too many students know how to add fractions but in real life are not able to apply it.

I think it is an excellent tool, especially for use in teacher training. Sell it to teachers' colleges first.

Great, if there is time. Curriculum demands make it difficult to use it much.

Site B

Excellent concept in keeping with the problem solving challenge of the eighties.

I like it generally, but as an auxiliary to the regular text and curriculum.

It is worthwhile teaching for problem solving. I'm glad I had the experience of working with it. I hope pupils will benefit. It will be part of my program.

Pretty good. I plan to use it more next year.

I enjoyed it. It was helpful to students.

I love it. It gears on thinking skills.

Good. It is helpful to teachers and pupils. It meets the needs of both.

If I was more at ease, I might teach it more.

Excellent.

Overall, good. It should start at grades 2 and 3. The workshops and math (content) seemed aimed at junior high school or higher. It needs more emphasis to lower grades.

I enjoyed participating and being exposed to activities. I will use it.

I enjoyed it.

I thought it was great and will miss people.

Excellent program. It lessens the problem of teaching problem solving. Problem solving could be improved in all areas of education.

Appendix B

The MANS Test

The MANS Tests

The MANS tests are short test scales originally designed to assess what are thought to be some of the underlying thinking skills of CSMP, an experimental mathematics curriculum developed by CEMREL, INc. They have been used in the evaluation of CSMP for several years in second through sixth grade studies.

Characteristics of the MANS tests include:

- Testing of important mathematical skills
- Situations presented are usually new to students
- Do not contain non-standard terminology
- Series of short scales, each preceeded by special directions and samples
- Provide for a mixture of multiple choice, open-ended, and multiple responses
- Require little reading, and when reading is required, the reading level is well below grade level
- Low algorithmic computational requirements
- Main unit of analysis is the classroom

For all MANS scales, an intensive pilot test and review procedure is used during the development phase. CSMP Evaluation Report $-B-3 contains a detailed description of this process for an earlier CSMP study.

A brief description of each test is given below. Similar tests have been grouped into categories of mathematical content.

Administering the MANS tests requires trained testers, who were given specific directions for administering the tests, as well as a standardized script which included sample problems from the scales. During the testing session students work a sample with the tester, then do the items in that scale on their own.

MANS tests are administered to intact classes, in two separate sessions which are usually scheduled on two consecutive days. Each session lasts from 45 to 55 minutes. Some scales, like Estimation, are strictly timed; for others timing is flexible.

Four categories of scales were administered to TOPS classes: Estimation and Mental Arithmetic, Fraction and Decimals, Represenations and Patterns of Numbers and Elucidation. In all, twenty scales were administered, the scales averaging 11 items per scale. Item sampling was done for most scales. A description of each category and a sample from each scale are shown below.

CATEGORY: ESTIMATION AND MENTAL ARITHMETIC

Includes two types of scales: Estimation requires the rapid deriving of approximate answers to problems; and Mental Arithmetic requires the exact answers to calculations amenable to non-algorithmic solution.

6 scales, 66 items

E1. Estimating Intervals: Addition

Abstract: Given a computation problem involving whole number addition, and 5 fixed intervals (0-10, 10-50, 50-100, 100-500, 500-1000), determine which interval contains the answer to the problem, and put an x in the interval. By instruction, format and short time limits, students are discouraged from computing exact answers. Two or three sample items are done collectively.

Specifics: 8 items, on one form taken by all students, exactly 1.75 minutes.

Examples:	479 + 85	0	10	50	100	500	1000
	19 + 19 + 19	0	10	50	100	500	1000

E2. Estimating Intervals: Subtraction

Abstract: The scale is similar to E1 (except that it involves whole number subtraction) and follows it directly in the test booklets.

Specifics: 8 items, on one form taken by all students, exactly 1.5 minutes.

Examples:	100 - 93	0	10	50	100	500	1000
	705 - 217	0	10	50	100	500	1000

E3. Estimating Intervals: Multiplication

Abstract: The scale is similar to E1 and E2 (but is devoted to multiplication with whole numbers for the most part) and follows them in the test booklets.

Specifics: 8 items, on one form taken by all students, exactly 1.5 minutes.

Examples:	40 x 10	0	10	50	100	500	1000
	4 x 29	0	10	50	100	500	1000

E4. Estimating Intervals: Division

Abstract: The scale is similar to E3 except that it involves division mostly of whole numbers and there are different intervals (0-1, 1-10, 10-20, 20-100, 100-500) in the response format. It follows E3 in the test booklets.

Specifics: 16 items, 8 on each of two forms, exactly 1.5 minutes.

Examples:						
	190 ÷ 10	0	1	10	20	100
	18,230 ÷ 1,000	0	1	10	20	100

E5. Whole Number Open Sentences

Abstract: Given an open sentence, where the box may be either on the right or the left of the equal sign, where the numbers are large and easy to work with, and where only one operation is used, put the number in the box which makes the sentence true. By instruction and prompting, students are discouraged from "computing the long way" and are not allowed to do any figuring on paper.

Specifics: 24 items, 12 on each of two forms, exactly 7 minutes. Twenty-one items are of Type A, three are of Type B.

Examples: Type A: 500 + 9,000 + 500 = $\square$

$\square$ - 250 = 150

12 x 50 = $\square$

900 divided by $\square$ = 3

Type B: 7 x 43 = 301
14 x 43 = $\square$

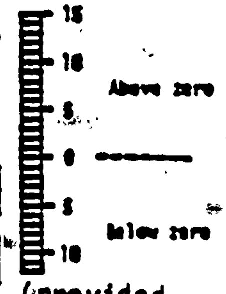
600 divided by 15 = 40
615 divided by 15 = $\square$

E6. Negative Hits and Misses

Abstract: Given the description of a "game" with two rules (a) each hit means a gain of 5 points and b) each miss means a loss of 1 point) and partial information on turns, the student must deduce the missing information. Two sample items are completed collectively.

Specifics: 10 items, 5 on each of two forms, approximately 4 minutes.

Examples:	Started with a score of	Number of Hits	Number of Misses	Ended with a score of
Jan:	3 above zero	0	7	
Peter:	10 below zero	1		12 below zero



(provided, but not mentioned in instructions)

CATEGORY: FRACTIONS AND DECIMALS

Requires computation with fractions and decimals in a variety of novel applications.

6 scales, 60 items

F1. Decimal Gas

Abstract: Solve word problems each of which start with 6.5 gallons of gas. The one-step solutions all require simple computations (+, -, x, or ÷) with decimals.

Specifics: 8 items, 4 on each of two forms, approximately 3 minutes

Examples: Peter has 6.5 gallons.
Then he spills 1.2 gallons.
How much gas will he have left? ________

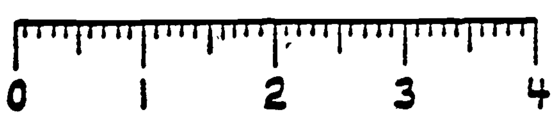
Ron has 6.5 gallons.
Next week he will use ten times this much.
How much gas will he use next week? ________

F2. Representing Fractions and Decimals

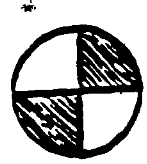
Abstract: The scale has five short subsections each containing one of two kinds of items: either a mixed number or decimal is given in standard form and must be represented in another specific way or else that process is reversed and the response format is multiple choice. Instruction is largely in the form of a written question or command at the beginning of each subsection.

Specifics: 20 items, 10 on each of two forms, approximately 4 minutes.

Examples: Put an arrow at 1.35 inches.



How much is shaded?



$\frac{1}{3}$ $\frac{1}{2}$ $\frac{2}{3}$ none of these

(A completed sample was given.)

F3. Fraction Computation

Abstract: Given straightforward computation items involving simple fractions, produce exact answers (by calculating on paper if necessary). Though the items do not have the multiple choice response format, they are similar in range and difficulty to those found in the standardized achievement tests of the appropriate grade level.

Specifics: 10 items, 5 on each of two forms, approximately 1 minute.

Examples: $\frac{1}{2} + \frac{1}{4} = \square$ $\frac{1}{3}$ of $15 = \square$

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F4. Fraction Open Sentences

Abstract: Given an open sentence involving at least one fraction, and one of the four arithmetic operations, complete the sentence.

Specifics: 6 items, on one form taken by half the students, approximately 3 minutes.

Examples: $\frac{3}{5} \div \square = 1$ $\qquad$ $\frac{3}{7} - \square = \frac{1}{7}$

F5. Which Fraction is Larger

Abstract: Given two non-whole numbers written in fractional form (a proper fraction, an improper fraction or a mixed number), circle the larger one. A completed sample item is shown.

Specifics: 6 items, on one form taken by half the students, approximately 2 minutes.

Examples: $\frac{3}{4}$ or $1\frac{1}{4}$

$3\frac{1}{2}$ or $\frac{5}{2}$

F6. Which Decimal is Larger

Abstract: Given two non-whole numbers written in decimal form, circle the larger one. A completed sample item is shown.

Specifics: 6 items, on one form taken by half the students, approximately 2 minutes. In one item, one of the numbers is written in fractional form.

Examples: 4.999 or 5.1

1.5 or 0.58

Requires finding or applying a given pattern in sets of numbers.

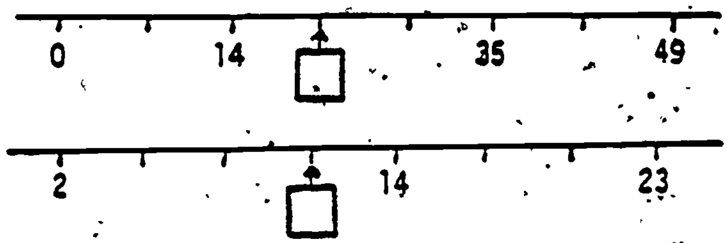
6 scales, 72 items

R1. Labelling Number Lines

Abstract: Given partially labelled number lines, with varying increments, determine certain missing numbers. A sample item is worked collectively.

Specifics: 10 items, 5 on each of two forms, approximately 5 minutes.

Examples:

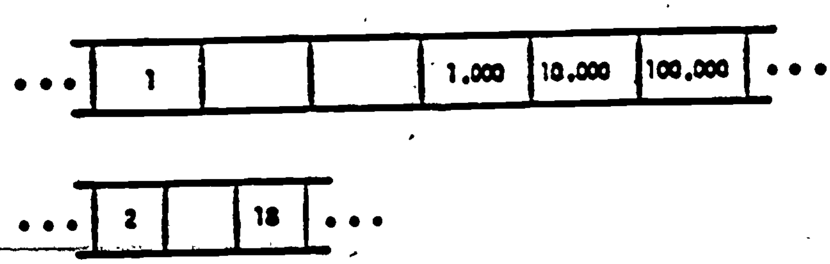


R2. Multiplication Series

Abstract: Given an incomplete portion of a multiplicative series of numbers, determine the constant multiplier involved in order to complete the portion shown. Portions of several series are shown altogether with one, two or three numbers missing from each. A sample series is examined and completed collectively.

Specifics: 14 items (missing numbers), 7 on each of two forms, approximately 3.5 minutes.

Examples:



R3. Constructing Numbers

Abstract: Given the use of only four digits (2, 5, 7 and 8) and the rule that no digit be used more than once, construct numbers like the smallest (or largest), the second smallest (or largest) or the closest to a given number. The constructed numbers are to be of either 2, 3 or 4 digits and sometimes restricted to a given range of numbers. Collectively, to clarify the rules, two incorrect answers and the correct one are examined for two sample problems.

Specifics: 12 items, 6 on each of two forms, approximately 4 minutes

Examples: What is the <u>second largest</u> four digit number? ______

What is the <u>smallest</u> three digit number between 730 and 850? ______

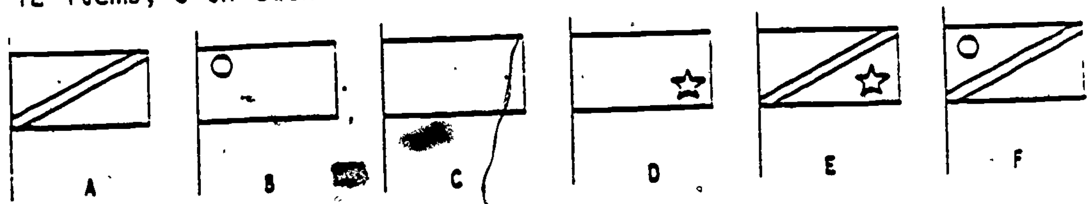
What four digit number between 2,000 and 3,000 is closest to 2,800? ______

R4. Attributes of Flags

Abstract: Given drawings of six flags which have different combinations of attributes, select the flag which is described by a statement.

Specifics: 12 items, 6 on each of two forms, approximately 6 minutes

Examples:



Sample: Beth likes flags that don't have a stripe or a star.
Which flags would she like?
Circle all the correct answers.

A B C D E F

In what ways are flags B and F alike?

R5. Solving Number Rules

Abstract: Given 3 clues (i.e., pairs of numbers) in a game, determine what the secret method is (i.e., the unique rule relating each of the pairs of numbers) and then use the rule to calculate the missing number from the fourth pair.

Specifics: 12 items, 6 on each of two forms, approximately 6 minutes. On half the items, it is the second number that is missing from the fourth pair; on the other half it's the first one that is missing.

Examples:

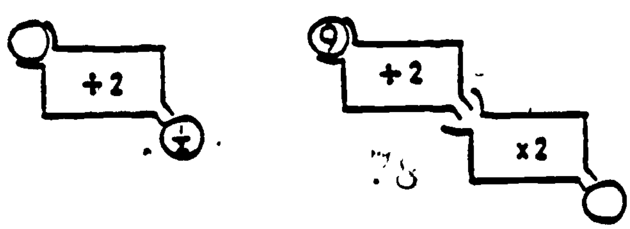
	Amy's Game		Jane's Game	
	Class said:	Amy's answer:	Class said:	Jane's answer:
First clue:	5	26	9	3
Second clue:	9	46	15	5
Third clue:	2	11	30	10
Question:	4	$\square$	$\square$	7

R6. Using Number Machines

Abstract: Given labelled "number machines" in sequence and either the initial or the terminating number, determine the other number. There is an introduction showing that "number machines" take in numbers; add, subtract, multiply or divide by a fixed quantity; and give out the resultant number. Then three sample items (each with a "number machine" sequence) are worked collectively.

Specifics: 12 items, 6 on each of two forms, approximately 4 minutes.

Examples:



CATEGORY: ELUCIDATION

Requires producing many correct answers to a given problem.

2 scales, 30, 34 possible correct answers

U1. Getting to 12

Abstract: Given a starting point (0), a goal (12) and two rules, invent as many ways of reaching the goal as possible. The rules are that only the numbers, 2, 3, 5, & 7 can be used along with addition, subtraction multiplication or division. Two sample solutions (see below) are worked collectively.

Specifics: Exactly 3.5 minutes.

Examples:

Example 1: 0 + 7 = 7
7 x 2 = 14
14 - 2 = 12

Example 2: 0 + 5 = 5
5 + 3 = 8
8 ÷ 2 = 4
4 x 3 = 12

U2. Producing Many Answers

Abstract: Given several different situations each of which poses a problem for which there are many correct solutions, produce as many of them as possible. For each situation, some potential solutions are accepted or rejected for not following the given rules as inappropriate.

Specifics: Four situations; only the first one is read by the tester. All students do the first two of four; do the remaining two on Form A; half do the remaining two on Form B. Total of 17 possible correct solutions to the first two and for the remaining two items fourteen correct for Form A; eighteen correct for Form B.

Examples: Rules: Start at zero.

Count by a number and end up at 24.

What would you be counting by? ~~7~~

Give all the correct answers. 6, ____________________

____

Rules: Use only even numbers. ~~5~~

They must be divisible by 5. ~~12~~

They must be smaller than 80. ~~100~~

Give all the correct answers. 60, ____________________

____

Appendix C

MANS Scores, Site A

List of Class Means, Site A
MANS Categories
TOPS/Non-TOPS

Classes	Estimation And Mental Arithmetic	Fractions and Decimals	Representations and Patterns of Numbers	Elucidation	Total	Figural Reasoning	1981 Reading
TOPS 1	34.7	27.4	40.5	32.9	135.8	7.8	24.4
2	31.2	25.8	37.9	24.4	119.3	8.3	17.4
3	31.9	24.2	31.8	12.9	100.8	6.6	17.4
4	33.3	21.2	35.2	17.2	106.9	8.0	15.6
5	45.2	41.9	48.6	39.4	175.1	9.1	24.8
6	33.0	22.7	34.8	16.2	106.7	7.7	14.6
Non-TOPS 1	27.8	20.1	27.6	19.3	94.7	7.6	22.5
2	41.1	28.0	39.5	24.7	133.2	8.4	17.2
3	28.7	21.7	31.5	16.6	98.5	7.7	16.1
4	29.0	24.9	32.5	17.0	103.4	8.1	19.9
5	38.0	32.4	40.5	32.3	143.3	8.6	23.3
6	28.5	20.2	32.5	33.0	114.3	8.5	22.0

Appendix D

California Achievement Test Scores Site B

List of Class Means, Site B
California Achievement Test Scores
1981-1982 Students

Classes	Computation	Concepts and Applications	Total	Reading
TOPS				
1	385.2	407.9	397.0	417.0
2	451.4	447.1	446.5	457.7
3	428.6	422.3	422.7	412.9
4	399.4	421.2	410.5	410.5
5	418.9	433.1	425.1	425.6
6	415.9	415.3	415.1	412.4
7	426.4	435.8	430.6	437.9
8	407.9	418.8	411.4	391.4
9	459.4	481.3	471.8	484.0
Non-TOPS				
1	401.8	405.8	404.3	436.1
2	439.9	446.9	441.0	478.1
3	418.5	438.9	427.7	431.2
4	379.6	394.8	388.2	389.9
5	418.8	430.3	424.2	418.6
6	409.1	417.4	411.8	406.5
7	442.4	440.3	439.1	447.2
8	418.0	423.2	419.0	396.1

List of Class Means, Site B
Fifth Grade Classes
TOPS/Non-TOPS

TOPS Class	Computation 1980-81	Computation 1981-82	Concepts and Applications 1980-81	Concepts and Applications 1981-82	Total Math 1980-81	Total Math 1981-82	Reading 1980-81
04	418.1	433.7	415.0	432.3	414.6	432.1	399.9
04	475.1	499.8	444.2	508.3	478.2	502.3	482.5
08	[illegible]	434.7	402.0	423.8	396.2	428.0	364.6
13	398.5	434.8	423.9	454.1	411.5	444.6	414.6
14	425.2	474.2	431.8	465.7	427.4	467.4	428.2
16	411.6	469.1	429.3	463.0	419.7	464.4	435.9

Non-TOPS Classes	Computation 1980-81	Computation 1981-82	Concepts and Applications 1980-81	Concepts and Applications 1981-82	Total Math 1980-81	Total Math 1981-82	Reading 1980-81
01	437.4	471.9	438.2	464.5	435.5	465.6	437.9
07	408.9	443.4	423.1	432.0	415.3	436.2	424.3
10	410.4	431.6	422.9	442.2	415.9	436.7	427.3
18	450.4	515.8	464.1	523.4	455.9	517.8	484.9